Chapter 6

Storage

6.1 BIOS

The term BIOS stands for *Basic Input Output System*. The BIOS is most commonly found on the motherboard. It is embedded on a chip called the BIOS ROM. (The term ROM stands for *Read Only Memory*, which means the BIOS ROM can only be read or is either difficult or impossible to be written into – no need, chap 1). In addition to this modern day computers may have a BIOS in their Video Graphics Adapter card, SCSI adapter card and network cards.

6.1.1 BIOS Basics

ROM is also referred to as non-volatile memory. This means that once the power of the computer is switched off, the data in the ROM chip will not be lost. This is the reason why the BIOS is written onto a ROM chip (figure 6s.1). The BIOS needs to be available every time the computer system is turned on. The main functionality of the BIOS is to load the basic drivers (a driver is a collection of functions which helps the processor to control and communicate with a device) from the chip to the memory so that the basic input and output devices like the keyboard, display, hard disk, CD-Rom drive, ports and the network card etc. can function correctly. Once these drivers are loaded, the system can start the operating system.

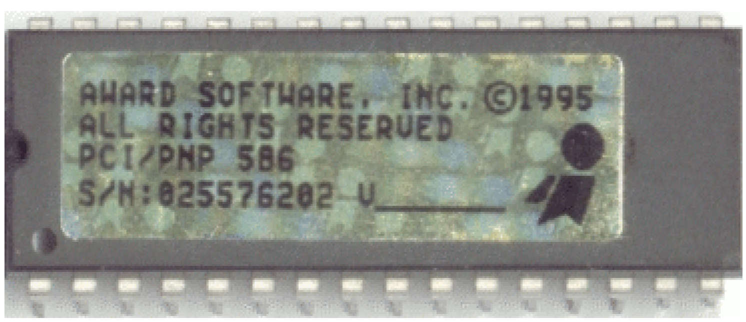

Figure 6.1: BIOS chip

The BIOS can be thought as a layer between the hardware and the operating system. You know that hardware is manufactured by different manufacturers work with the same operating system. The reason for this is that the BIOS create a standardized interface for the operating system to communicate with the hardware. This implies that the BIOS is different from hardware to hardware but always has the same interface for the operating system.

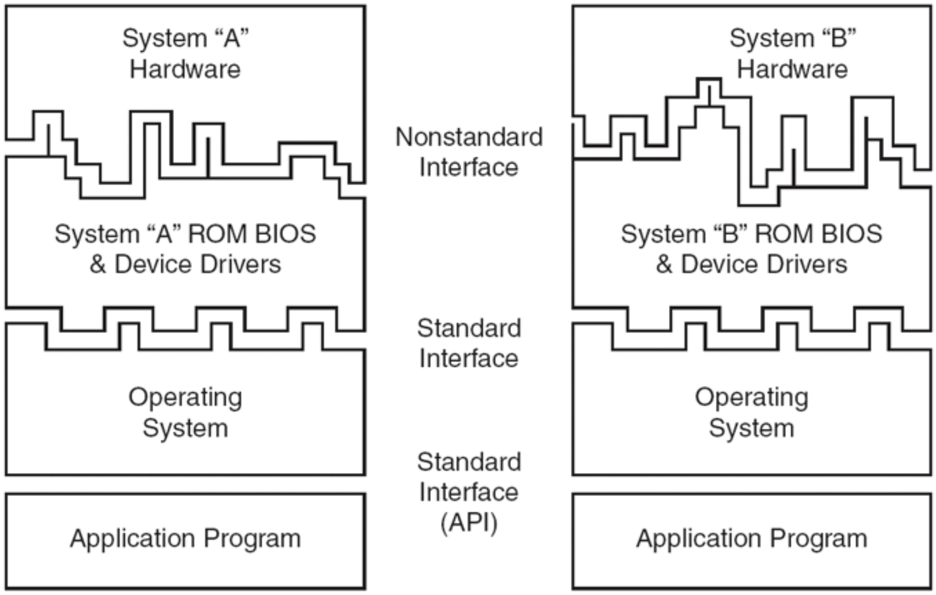

Figure 6.2: Layers between Hardware and the OS

The BIOS can be viewed from two different aspects:

- **Hardware** – The BIOS is consists of a ROM chip that is most commonly plugged into the motherboard. In modern systems BIOS chips are also available on interface and adapter cards like the VGA card, SCSI adapter and Network interface card. The BIOS chips could be of type True-ROM, Programmable ROM (PROM), Electronically Programmable ROM (EPROM) or Electronically Erasable Programmable ROM (EEPROM).
    1. If the writing (Burnt, embedded) into the chip occurs during the manufacture, it is known as a *True-ROM*.
    2. If the writing is after manufacture and the chip cannot be re-written (written only once), it is known as a *PROM*.
    3. If the writing is after manufacture and the chip can be erased using UV (Ultra Violet) light and re-written (writable multiple times), it is known as an *EPROM*.
    4. If the writing is after manufacture and the chip can be erased electronically and re-written, it is known as a *EEPROM*.

  Most modern day motherboard BIOS chips are EEPROMs, hence we could easily do a BIOS upgrade (Burn a newer version of the BIOS software). It important to note that the BIOS comes paired with a CMOS (CMOS – Complementary Metal Oxide Semiconductor. This chip is the most prominent CMOS type chip in the computer system. Hence it is referred to as the CMOS chip) chip which is a RAM chip but uses very little power. This chip stores the BIOS settings since the configuration cannot be written into the BIOS chip itself since it's a ROM.
- **Software** – A BIOS is embedded on a device or card that needs the drivers to initiate itself before the operating system can load any drivers. The BIOS mainly consists of standard drivers for the primary input and output devices, and other

components like motherboard, memory and on-board interfaces. These drivers enable the processor to communicate and control the devices. Without drivers the processor would not know how to control and communicate with the devices. It would be like two people who do not understand one another's language trying to communicate with each other. This would lead to total chaos in the computer. Hence, if a device does not have a proper driver that device is considered as a non-functioning device by the computer.

In addition to the Drivers the BIOS has three other functions. They are:

1. POST – Power On Self Test – This is a program that carries out a test of the basic components of the system, like the processor, motherboard, memory, keyboard, display, and ports etc.. This program is run when the computer is turned on. If any of the primary devices do not function the computer will halt the start-up process. More explanations about the POST test are available in section.
2. Setup –This is a program that enables you to configure the system. These configurations include the CPU clock settings, primary and secondary boot devices selection, drive configurations, on-board interface configuration, date and time settings and many others. These configuration settings are saved on the CMOS chip of your computer. The CMOS chip is manufactured using Complementary Metal Oxide Semiconductor technology and hence referred to as the CMOS chip (repetition). This chip RAM and has a volatile memory (Data is lost when the power is turned off). Therefore the CMOS chip requires a battery to provide it with power when the computer is turned off to have the configuration setting saved on it preserved for the next time you turn on your computer. This battery is referred to as the CMOS battery, and the CMOS chip only uses only about one-millionth of an Amp of current to function.
3. Boot strap loader – The boot strap loader is a routine that reads the first sector of the primary drive and the secondary drive and so on until a master boot record (MBR) is located. Once it finds the MBR it loads it onto the memory and executes the code in it. The MBR then loads the volume boot record (VBR) to memory. The execution of the VBR code loads and executes the operating system start-up file.

6.1.2 BIOS Settings

In addition to viewing of the BIOS from the hardware and software perspective, we have to consider the configuration of the BIOS. This mainly applies to the motherboard BIOS and the *Setup* programme. Some of these settings can be changed while the others are intended only to provide information. If you are not sure of some settings leave it at "Auto" or "Default". Most setup options are common to all BIOS setup programs and in many cases only the appearance and locations of setup options change.

Listed below are some of the most commonly required configuration settings of a motherboard BIOS manufactured by AWARD (a company that manufactures BIOS).

- Standard CMOS Features
    1. Date and Time Settings – This allows you to change the data and time settings of your computer.
    2. Primary and Secondary IDE Devices – This allows you to detect and configure devices like hard drives and CD/DVD drives. Since there are usually two IDE interfaces the first in known as the Primary (IDE1) and the second is known as Secondary (IDE2). (Usually the Primary Master is the hard drive with the operating system).
    3. Drive A and B enable/disable – This allows you to enable the floppy drives (Usually you would have only one floppy drive which will be Drive A. Hence, disable Drive B)
    4. Video type – This allows you to specify the type of video you are using (Usually EGA/VGA).
    5. Information – Some other information like the amount of memory is displayed here. These are not changeable.
- Advanced BIOS Features
    1. Anti-Virus – Some BIOS have built in anti-virus programs, enabled it to protect your system
    2. Cache – This allows you to enable the Cache for better performance of your computer.
    3. Processor features – This allows you to enable processor features to improve the performance of your computer (the processor must support the enabled features).
    4. Quick POST – This allows you to enabling the Quick Power On Self Test for faster boot-up (Some of the test will not be done).
    5. Boot sequence – This allows you to select the order of devices to boot from (Suggested order: Primary Hard disk, CD-Drive and Floppy – to avoid accidental booting from CD or floppy which could cause a virus infection threat).
    6. Swap Floppy Drive – This allows you to set the physical drive A as logical drive B if you have two floppy drives. It allows you to change the name of the two floppy disks without changing the connectors.
    7. Boot Num lock – This allows you to enable Num lock On at boot-up so that every time you boot-up the computer the Num Lock will be On.
    8. PCI/VGA Palette Snoop – Should be always enabled unless you have a PCI and an ISA VGA card installed
    9. PS/2 Mouse Function Control – This will allow you to turns the PS/2 mouse On and Off.
    10. BIOS write protect – This allows you to enable BIOS write protect to safeguard your system from accidental or virus overwriting of your BIOS.
- Advanced Chipset Features
    1. DRAM Clock – This allows you to set the memory frequency, it is best you leave this setting as Auto.

2. Prefetch Cache – This allows you to enable prefetch cache for better performance of your computer.
3. System BIOS cacheable – This allows you to enable the system BIOS cacheable for better performance so that the BIOS need not be read always.
4. Video BIOS cacheable – This allows you to shadow the firmware on the RAM memory, which achieves better performance, but reduces the amount of memory available for other devices.

- Integrated Peripheral – This allows you to select the PI/O Mode for hard disk, support for USB devices, parallel and serial port settings.
- Power management Setup
    1. Power Management – This allows you to specify the power management mode among User Defined, Max Saving and Min Saving. If you want to manually set the parameters you have to select User defined.
    2. APM – APM provides better power management.
    3. Video Off Method – This specify the signal sent to the monitor when the power management is applied.
    4. Video Off After – This specifies the mode used to turn the monitor off.
    5. Doze Mode – This specifies the waiting time before the computer goes to Doze mode. In Doze mode the CPU frequency is reduced
    6. Standby Mode – This specifies the waiting time before the system goes on Standby mode. In Standby mode the monitor and the hard disk are turned off but the other peripherals stay on.
    7. Suspend Mode – This specifies the waiting time before the system goes on Suspend mode. In Suspend mode all peripherals are turned off except the CPU.
    8. HDD Power Down – This specifies the waiting time before the disk turned off
    9. Soft-Off by PWR-BTTN – This specifies how long you must press and hold the power button before the system is shut down (supported only by ATX motherboards).
- PnP/PCI Configuration – This has the settings of your Plug n Play hardware device configuration. Leave these as Default settings, change them only if you require a specific setting and you know how to.
- PC health Status – These settings will help you to keep track of CPU temperature, Fan Speeds, Chassis temperature, Voltages in your computer and other critical information.
- Load Setup Defaults – This allows you to load the default setting of the BIOS.
- Password Settings – This allows you to enter a password which prevents other users from changing your BIOS settings.
- Save & Exit Setup – This allows you to save changes you made when exiting the Setup.
- Exit Without Saving This will exit the Setup without saving the changes.

It is important to note that different manufacturers of BIOS have different setup programmes. Furthermore different BIOS versions are manufactured for different hardware configurations. For example if the motherboard has on-board sound and graphics, there will be special options in the setup program to enable/disable them. If the motherboard does not have the on-board sound and graphics these options will not be available.

The important fact is that operating systems integrate with most standard BIOS version, so that the user does not feel any difference whether he is using a BIOS manufactured by AWARD, AMI or PHOENIX.

6.2 Volatile Storage (Memory)

Even though volatile and non-volatile are two instances of memory, in this section we will talk about volatile memory. The term volatile implies that once the power is turned off the data in the memory is lost. The most popular memory is the computer is the main memory (also commonly referred to as RAM or simply memory) and cache memory.

6.2.1 Memory types and their relevance to different applications

Memory comes in three types.

1. ROM - This has been discussed in section. Even though ROM stand for Read Only Memory it is important to note that ROM is also accessed randomly.
2. DRAM - Main memory or RAM as commonly called is the most common use of the type Dynamic Random Access Memory or DRAM in the computer. The reason this type of memory to be referred to as dynamic is the memory needs to be refreshed every 15 nanoseconds. If this refresh is not done the data in the memory is lost. Due to the requirement of refreshing the DRAM is comparatively much slower than SRAM. This is a draw back of DRAM. The advantage of DRAM is that the cost of DRAM is low. Currently 1Mb of DRAM costs less than twenty five rupees. The average size of main memory of current personal computers is about 256Mb and most motherboards support up to about 4Gb of memory.

   RAMs or Memory (figure 6.3) is where the instructions and data used during processing are stored temporarily. This is referred to as the workspace of the processor. A copy of the program and data needed are loaded (copied) to the memory from a hard disk, CD, floppy disk or any other permanent storage device (devices which do not loose the data once the power is turned off). Then the processor uses this program and data and does the processing. The original copy of the program remains unchanged in the permanent storage device. If there is a large amount of memory space available a number of programs and a large amount of data can be loaded to the memory simultaneously.

Figure 6.3: Random Access Memory module

3. SRAM - The most common use of Static Random Access Memory or SRAM is for the Cache memory. Here the word static implies that the memory does not require refreshing to keep data. This has made the SRAM much faster than DRAM. Since the cache has to function close to the speed of the processor, SRAM is used as cache memory. In most modern computers we talk about level 1 and level 2 caches. Unlike main memory when talking about the cache, we refer to cache size in kilobytes. The largest amount of cache you would normally find in a personal computer is about 1Mb or 2Mb. In addition to some technical reasons, the most prominent reason for the cache memory being of limited size is the cost. SRAM is very expensive compared to DRAM.

RAM Types

There are different types of RAM used in computer systems. Some of them are still used and the others have become obsolete. Explained below are the types of RAMs used in computer systems.

1. Fast Page Mode DRAM (FPRAM) - The old 486 and Pentium computers used FPRAM. These types of RAM have longtime become obsolete. This memory is accessed in pages (a page is a contiguous set of memory locations) instead of a single memory location (a logical are in memory where a single part of data is stored) at a time. This helped in making memory access faster since data and instructions are normally contiguous (the next instruction to be executed is usually in the next memory location).
2. Extended Data Out RAM (EDORAM) - This type of memory was available in Pentium computers. These were also referred to as *Hyper Page mode* memory since they were an improved version of the FPRAM. These were ideal for computers with data bus speeds (The number of times per second data can be exchanged on the wires that carries data between the processor and memory) of 66MHz.
3. Synchronous DRAM (SDRAM) - These RAMs are function in synchronous with the motherboard clock. This removes the drawback of latency due to asynchronous function of memory. These have a much faster speed than EDORAMs due to this reason. SDRAMs function at clock speeds of 66MHz, 100MHz and 133MHz. These have specifications called PC66, PC100 and PC133 respectively. SDRAMs are still used in computers that were manufactured during the late 1990s and early 2000s. SDRAMs reached their height of development at 133MHz.

4. Double Data Rate SDRAM (DDR SDRAM) - To go beyond the 133MHz barrier the computer manufacturer developed the DDR SDRAM. The data transfer on a normal SDRAM occurs on the rising edge of the motherboard clock cycle. But the DDR SDRAM, the transfer of data occurred on the rising edge as well as the falling edge of the clock cycle. This simply increased the speed of memory by twofold. This concept is shown in figure. Most computers manufactured during the early 2000s use the DDR SDRAM technology. These memory modules were designed with 184 pins. These could function at clock speeds ranging from 100MHz to 266MHz, which effectively provided bus speeds of 200MHz to 533 MHz due to the double data rate. These have specifications ranging from PC1600 (1600 implies the bus speed multiplied by the bus width - 200 x 8 = 1600) to PC4300.
5. DDR2 SDRAM - This is a simply faster version of the DDR SDRAM. These use differential pairs of signal wires to avoid noise and interference of data transfer. These RAMs have 240 pins to achieve this. The bus speed of DDR2 SDRAMs starts at 400MHz and goes up to 800MHz. These have specifications ranging from PC23200 to PC26400. Another advantage is that DDR2 uses only 1.8v voltage unlike the DDR which uses 2.5v voltage. Hence the power consumption and heat generation is reduced. The DDR2 SDRAMs were introduced around the year 2004. G-DDR2 (Graphics DDR2) is a variant of the DDR2 which is used for high end video graphic adapter cards.
6. Rambus DRAM (RDRAM) - RDRAMs were designed for high end computers in the late 1990s and early 2000s. These had very high bus speeds and followed the concept of having a direct data path between the processor and memory, bypassing the traditional memory buses of the computer. Even though The Intel cooperation was involved in the initiation the RDRAM, it later concentrated more on supporting DDR and DDR2 systems. Due to lack of support the RDRAM is likely to wither away. The RDRAM supported bus speeds of 400MHz, 533MHz and 800MHz. This was equivalent to the current DDR2 memory speeds.

Cache Memory

The memory is about eight times slower than the speed of the modern day processors. Therefore if the processor had to read data from the main memory all the time, it would dramatically reduce the performance of the processor. To avoid this problem, computer manufacturers have developed the cache memory. The cache memory is manufactured using SRAM technology and functions at speeds compatible with the processor. The cache has only a small storage capacity relative to the main memory. Hence, most frequently used instructions and programs are loaded to the cache memory. If a cache-miss (the instruction or data is not in the cache) occurs, the processor then has to look in the main memory for it.

Cache comes as *Level 1 (L1)*, *Level 2 (L2)* and *Level 3 (L3)*. Previously only L1 cache memory was on the processor die (the die is a part of the silicon wafer the processor is manufactured from) and the L2 cache was external. Hence L1 was referred to as the *internal cache* and the L2 cache was referred to as the *external cache*. In modern day computers the L2 cache is also embedded on the processor die. The L3 cache is normally found on high end machine such as servers.

6.3 Non-volatile Storage Devices

Non-volatile storage devices referrer to devices that do not loose its data once the power is turned off. These devices may store data permanently or semi-permanently. If it is stored permanently it cannot be overwritten. An example for this is a CD-ROM or writable CDs. If it is stored semi-permanently the data will remain on the device until it is deliberately overwritten or erased. Hard-disks, Rewritable CDs, floppy disks and Flash drives are examples semi-permanent storage devices.

Non-volatile storage devices can be further categorised according to the different technologies used by them to store data. The primary technologies are magnetic, optical and Electronically Erasable and Programmable ROM (Flash ROM). Let us look at each of these in detail.

6.3.1 Magnetic Storage Devices

Magnetic storage devices use magnetism to store data permanently. These devices use platters or tape coated with magnetised particles. A read-write head (a device that can read magnetic fields of magnetised particles and create magnetic fields to orient magnetised particles) is used to read and write data to and from the platters or tape. Unless the orientation of these particles is deliberately changed they remain unchanged even when the power is turned off. Hence, we have non-volatile storage. Figure 6.4 shows a magnetic tape.

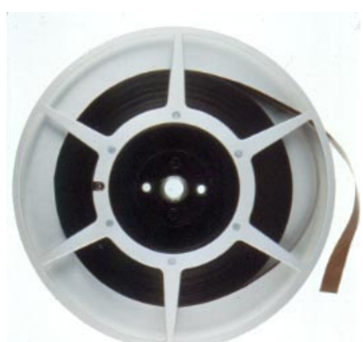

Figure 6.4: Magnetic tape

Since the computer deals with binary data, by orienting the magnetised particles in two opposite directions we can emulate a 1 or a 0. When writing data onto a magnetic device the head will orient the magnetised particles in one direction to indicate a 1 and in the opposite directions to indicate a 0. This is depicted in figure . When reading data, the head will pass over each storage location and will read the direction of the magnetic field created by the magnetised particles. If the field in one direction implies a 1, the field in the opposite direction will indicate a 0. This concept is depicted in figure 6.5.

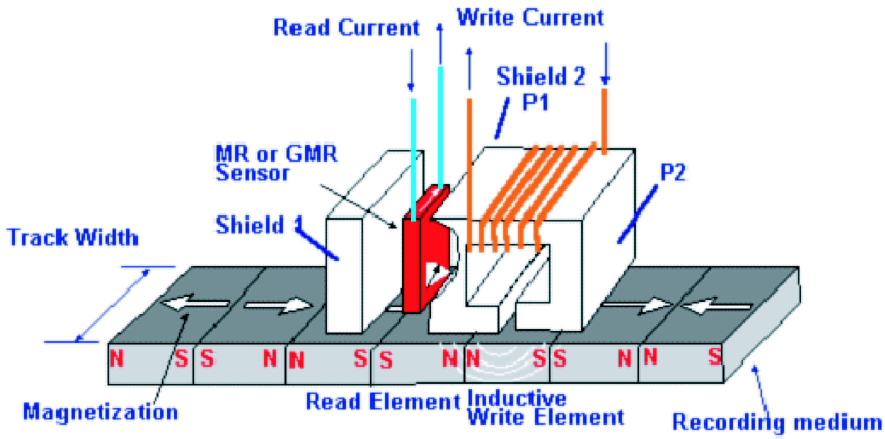

Figure 6.5: Reading and Writing to Magnetic media

6.3.1.1 Fixed Storage Devices

As the term implies fixed storage devices mean that the device is fixed onto the computer and is not meant to be portable. Furthermore these devices are not meant to be inserted or removed while the computer is on. Attempt to insert or remove these devices when the computer is on would damage the device or other components of the computer. This ensures that the software and data that is required by the computer system to function is always available. Fixed devices that support removal when the computer is in an On-state are known as Hot-swappable devices. These devices are not available in the common PC, but are available on servers which need to be running all the time.

6.3.1.1.1 Hard Disks

The hard disk in almost all instances is the main fixed storage device. The operating system and other software required by the computer and user are installed (systematically written to the hard disk and configured) on the hard disk. Furthermore any data and information that needs to be stored are also saved on the hard disk.

Let us consider an example to further understand the concept of a hard disk. Assume that you are writing a long document which you will not complete in one go. The document editing software is installed on the hard disk and this program will be loaded onto the memory. When you create and save a document it will write the data onto the hard disk. Once you finish for the moment, you will save the changes to the original document file and close the document editing program. Next time you need to edit this document file you will load the document editing software to the memory and it in turn will load the document file to the memory. You can now make any changes to the document. If you do not save these changes the file on the hard disk will not be affected. If you save the changes the file on the hard disk will be updated with the changes you have made. It is important to note that no changes have occurred to the document editing program, and it remains the same.

The hard disk is an electro-mechanical device that is usually sealed inside a case. The hard disk comprises of a set of platters which are coated with magnetized particles on both sides of each platter. This platters or in other words disks are not flexible, hence the term *Hard disk*. Furthermore these disks are fixed (there are exceptions), so the hard disk is also referred to as a *Fixed disk drive*. The hard disk usually referrers to the whole device instead of only the platters.

The platters are connected at the centre to a spindle (a shaft that is connected to a motor which rotates the platters). The platters have two heads on either side to read and write to them. For example, if there are six disks you would find twelve heads. These heads are connected to head arms which are connected to the head actuator (this moves the head arms which in turn moves the heads). The whole apparatus is mounted inside a chassis that is sealed to avoid foreign matter getting into the device and damaging it. It is important to note that a hard disk should not be opened-up, since a single dust particle would damage the read/write heads and renders it useless. The heads are so small that a dust particle appears like a huge bolder to it (figure 6.6).

Figure 6.6: Inside a hard disk

Modern hard disks are commonly available in 3inch for normal desktop computers and 2inch for notebook computers. The hard disk storage capacity has increased from about 5Mb (note megabytes) to over 250Gb (note gigabytes) over the past twenty five years. The cost of 1Gb of storage nowadays is about forty to fifty rupees. Hence storage space for data is no longer an issue, and discarding of data is not considered an important task.

The drive speed is an important parameter of hard disks. The speed is measured in revolutions per minute (rpm). The drives in modern computers usually are rated at 5400rpm or 7200rpm. While the drives in high-end servers and workstations are about 10000rpm or 15000rpm. The notebook hard disks function at about 4200rpm to conserve power. The higher the speed the faster the head can seek a particular location (known as the seek time). If the seek time is low, it means that data can be read faster from the hard disk. Reducing the read time is important since the hard disk stores most of the programs and data that is loaded to the memory for the processor to use.

Another important concept in hard disks, in fact in many storage devices is the division of the disk into *track* and *sector*. As the term implies the track can be seen as a single ring of storage area that runs on one side of the disk with a common centre as the disk itself. The tracks become smaller and smaller in size as they become closer and closer to the centre and thus the storage capacity of each tracks vary. If one takes all the tracks of similar radius of a set of platters and pile them one on top of the other you would get a cylindrical shape. Hence the number of tracks per disk is equal to the number of *cylinders* in a hard disk. Sectors are added to this division of the hard disk since the data stored in a single track is too large to manage with some track capable of storing over 100000 bytes. Like cutting a pizza into wedges, the disks are divided into sectors. The usual size of sectors is 512 bytes. The creation of tracks and sectors is done during a process called low-level formatting.

The capacity of a hard disk is calculated using the following formula.

D = disk capacity (bytes)

t = number of cylinders (cylinder)

h = number of heads

s = number of sectors per cylinder (sectors/cylinder)

c = capacity of a sector (bytes/sector)

$d = t \times h \times s \times c$

There are many developments happening in the world of hard disks. The older ATA (also called IDE) hard disks (figures ?, ?) have data transfer rates ranging from 33Mb/s (ATA-33) to 133Mb/s (ATA-133). The modern Serial-ATA (SATA) disks function at data transfer rates ranging from 150Mb/s (SATA/150) to 300 Mb/s (SATA/300). The newest development in progress is to increase the data transfer rate to 600Mb/s (SATA/600) in the SATA hard disk.

Figure 6.7: An ATA hard disk

Figure 6.8: Driver electronics of an ATA hard disk

Installing the hard disk

There are two connectors in the hard disk. One is to provide power and the other to transfer data and control information. Furthermore there are jumpers in the hard disk that allow you to configure the hard disk. Let us look at each one of these separately.

- Power – The power to the ATA hard disk is provided through a *Molex plug* power connector. The Molex plug is a “D” shaped connector which allows the power to be connected only in one way. The Molex connector should have tight fix, if not try changing the Molex connector you are using. If the power connector is loose, it could easily damage your hard disk as well as your computer.

  In the SATA hard disk there is a special power connector which is meant for SATA drives and connects only in one direction.

- Data cable – The data cable is plugged into the IDE port in the motherboard and the ATA hard disk. There are two types of IDE data cables, one with 40 wires and the other with 80 wires. The 80 wire data cable was introduced with the ATA-133 hard disks. The end that is plugged into the motherboard is usually not defined in the 40 wire cable, so any of the three connectors (middle or either of the two ends) can be plugged into the motherboard and the remaining two to any drive. The 80 wire cable usually indicates the connector that is to be plugged into the motherboard in a different colour. Another way of identifying this is that the middle connector is located not exactly in the middle but more closer to one of the end connectors. The connector at opposite end is the one which connects to the mother board. Furthermore there are keys in these connectors that help to connect the data cable in a correct direction.

  The SATA has a special SATA-data cable that can only be connected in one way to the SATA hard disk (figures 6.9, 6.10) and the motherboard SATA connection.

Figure 6.9: A SATA hard disk

Figure 6.10: Driver electronics of a SATA hard disk

- Jumpers – The hard disk consists of a jumper that determines whether the drive is considered as the *Master*, *Slave* or whether you let the “cable” select which is Master and which is Slave. This is required when connecting two drives (may be two hard disks, one hard disk and one CD/DVD drive or two CD/DVD drives) to the same data cable.

  When connecting two drives usually the hard disk with the operating system is set to be the Master drive and the other hard disk or CD/DVD drive is set to be the Slave drive. When allowing the cable to select the drive the jumpers on both drives are set to Cable Select position (Usually the drive at the end is set as Master and the drive at the middle is set as Slave, but this may change according to the cable used).

6.3.1.2 Removable Storage Devices

Removable unlike fixed drives can be inserted or removed from the computer even when the computer is on. This is not the case for fixed drives like the hard disk which should not be inserted or removed when the power is on. Removable devices are commonly used to backup or transport data. It can be simply inserted into the computer, date is read or written to it and once finished it can be removed from the computer without any hassle.

6.3.1.2.1 Floppy disks

The reason for floppy disk to be called as such was that the storage medium in the floppy disk is flexible. The original floppy had a disk that was 8 inches in diameter with a protective cover. Later the floppy disk was developed in sizes of 5inches (figure 6.12) (minifloppy) and 3inches diameter (microfloppy). The microfloppy emerged to be the most successful floppy disk and is still used by many (figure 6.11).

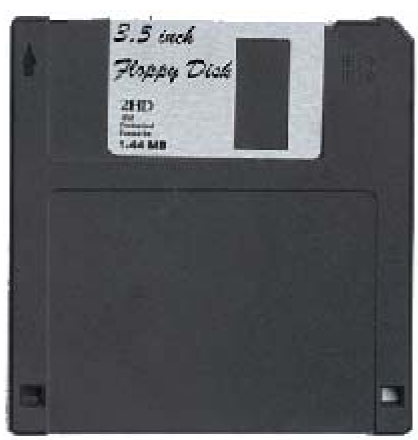

Figure 6.11: 3 ½ Floppy disk

Figure 6.12: 5 ¼ floppy disk

The floppy disk was the most prominent and common removable storage device till recent times. The floppy disk has now been replaced by higher capacity devices like the ThumbDrive (a USB flash memory device) and CD-R (writeable Compact Disk) and CD-RW (Re-writable Compact Disk). Even though, the floppy disk is still used as a primary boot device, for system installation and configuration, and troubleshooting a computer. The floppy disk is still the primary device for booting older computers that do not support booting off a CD.

The floppy disk is not considered a primary storage device anymore. This is obvious through that fact that many computer manufacturers are doing away with the floppy drive and adding more USB ports and memory card readers into their computers. This trend was started by notebook manufacturers, where if you need a floppy drive it has to be plugged into the computer as an external USB device.

Installing the Floppy drive

Most motherboard manufacturers still support the floppy drive connector. Like the hard disk the floppy disk uses two connectors, one for power and the other to transfer data. The power connector that provides the power to the microfloppy disk drive is referred to as the *mini plug*. The *Molex plug* is used to connect the power to the minifloppy disk drive. The miniplug has a special key that makes sure that the power is connected in the right manner. Furthermore the mini plug has special clips to lock in the power connector to the disk drive. The Molex plug has a special “D” shape which enables the power to be plugged in one way.

The data/control cable that connects the floppy drive to the motherboard usually comes with support for two drives. The connector at the end (the connector after the twist in the cable) is connected to Drive A (the primary of the two floppy drives). The middle connector is used to connect to Drive B (the secondary floppy drive). The other end is connected to the motherboard floppy connector. In older systems Drive A was a microfloppy drive and Drive B was a minifloppy drive. The twist in the cable is used to send a differentiating signal to identify drive A and B.

There are keys in all three of these connectors to avoid the improper installation of this cable. Sometimes the floppy drive may not provide such a key, in such a case usually pin 1 (the wire which has a different marking line on the data cable) is fixed towards the side of the power connector. Another method of identifying the improper installation of the cable is when the floppy indicator LED is always in an On state.

It is important to note that the read/write head of the floppy drive gathers debris. The head should be cleaned regularly using a floppy drive cleaner disk.

6.3.1.2.2 Magnetic drives

In addition to the floppy disk there are other removable magnetic storage devices. Many of these are of similar in style to the floppy disk, but may vary in thickness and sometimes shape. These devices have a large much larger storage capacity than floppy disks and were originally developed to replace the floppy disk. The main cause of the failure of these disks in achieving this goal was caused due to the reason that many of these devices were proprietary, which made them not as cheap as devices that could be manufactured by anyone. The CD-RW and DVD-RW became successors to the floppy but since late the ThumbDrvie has taken the computer word by storm. A brief introduction to some of these removable magnetic storage devices are given below.

- Iomega Zip – This is commonly referred to as the Zip disk (figure 6.13). The Zip disk comes in capacities of 100Mb, 250Mb and 750Mb and requires a special drive to read from and write to it known as the zip drive. The Zip drive can be connected to the computer using ATA (IDE connector), SCSI, USB, FirWire or Parallel interfaces (the first two are internal and the latter are external drives).

Figure 6.13: Zip disk

- SuperDisk – The SuperDisk comes in two models, the LS-120 and the LS-240. The SuperDisk has a special drive which can read from and write to both SuperDisks and microfloppy disks. This drive uses *floptical technology*. Floptical technology uses optics to track the precise location of the read/write head on the floppy media and then uses magnetism to read from and write to the floppy media. A LS-120 disk can store 120Mb of data and the LS-240 can store 240Mb of data.

Using the LS-240 drive, 32Mb can be stored in a microfloppy disk which usually can only store 1.44Mb.

- Iomega Jaz – This is a drive which is considered as a drive with the capacity range of hard disks (capacity measured in gigabytes). The Jaz drive is available in capacities of 1Gb and 2Gb. Unlike the previously mentioned disks this uses hard disk technology instead of floppy media. The platters, heads and motors are located inside an enclosure. The Jaz drive has a special drive which can be either internal or external to connect the Jaz drive to the computer.
- Castlewood Orb – Like the Jaz drive this drive too is considered as a drive with the capacity range of hard disks (capacity measured in gigabytes). The Orb disk has a capacity from about 2.2Gb to about 5.7Gb but is nearly the size of a floppy disk. The IDE or SCSI interfaces are used to connect the internal version and the Parallel, SCSI, USB, or Firewire interfaces are used to connect the external version.

External Hard drives

External hard drives use the same hard disk used as an internal drive, but they have a special housing that enables them to be connected via an USB, FireWire, SCSI or Parallel interface. Even though the 3inch hard disk is used for this purpose, the most commonly used is the 2inch notebook hard disk, which is much more compact in size and light weight. Another advantage of using the notebook hard disk is that it does not require a special external power connection like the 3inch hard disk, but uses the power available in the USB or FireWire port.

6.3.2 Optical Storage Devices

Unlike magnetic storage devices which use magnetism to read and write data, optical storage devices use light to read data and in some occasions write data. Unlike magnetic storage devices which can be read and written to multiple times, in most cases optical storage devices are either read-only or write-once. Another difference between magnetic storage devices and optical storage devices it that we call magnetic ones “disk” and optical ones “disc” (E.g. Hard disk and Compact disc). It is also important to note that some storage devices use both magnetism and light (E.g. SuperDisk).

The optical storage devices were developed with an intention of replacing magnetic storage, but the magnetic storage devices had higher data density and were much faster in reading and writing data. Hence, optical storage devices never became the primary storage device in computers. Optical storage devices now play the role of backup and archival storage device replacing the floppy disk.

6.3.2.1 Compact Disc

The first Compact Disc (CD) (figure 6.14) standard was the CD-DA (Compact Disc Digital Audio). CD-DA was released by Philips and Sony, and is the official designation for the audio-only format on CD. An audio CD contain up to 74 minutes and 30 seconds of hi-fi stereo or quadraphonic (four channel) sound. The audio is converted into binary code by sampling the sound waves at 44.1KHz (the audio signal is converted to a digital signal represented by a 16-bit number, 44100 times a second) and storing each sample as a 16-bit number. The specifications for the layout of a CD-DA are in the Red Book (the Red Book term is used since the cover of the book was coloured red). Hence CD-DA is referred to as the Red Book format.

Figure 6.14: Compact disc

The CD Drive: The device that is used to read the data from the CD is known as the CD Drive. The CD drive has laser emitting diode that emits a low intensity laser beam. The laser beam is reflected towards the CD using a mirror. This mirror is moved using a servo motor which is controlled by the microprocessor of the drive, so that the laser beam is positioned onto the correct track (similar to a track in a hard disk) of the CD. The spindle rotates the CD so that the entire track can be read. The laser beam reflected by the CD is focussed by a lens and reflected by the same mirror used to position the laser beam. The reflected laser beam is picked up by a photo detector that converts the light into an electric pulse. The drives microprocessor decodes these electric pulses and sends it as data to the computer.

How a CD works: The data in a CD is stored as a set of *lands* and *pits*. When reading a CD the laser beam shone on the underside of the CD. The top side of the CD is coated with a reflective layer (the top side of the CD is the label and the bottom side is transparent and close to the lens). When the laser beam hits a “land" it is reflected but when it hits a “pit" it is not. When the laser beam enters a “pit" the reflection changes from *reflected to not (yes to no)* and when the laser beam exits a “pit" the reflection changes from *not to reflected (no to yes)*. When ever the microprocessor receives “yes to no" or a “no to yes" it considers this as a binary 1. When there is no transition the microprocessor considers them as a binary 0. The reflections are translated into bit patterns to create a digital stream of sound or data.

Even though the CD was intended to be a read only device, with the introduction of CD-R and CD-RW, CDs have become one of the most popular and economical mediums for data storage.

CD-ROM

The Compact Disc Read Only Memory (CD-ROM) is based on the original CD-DA format. The CD-ROM was released as a Yellow Book format (since the cover of the book which contained the standard was yellow). Even though the CD-ROM followed the same standards as the CD-DA it had modified decoding electronics to make data storage more reliable. The electronics of a CD-ROM device has the added capability of error detection and correction. This is essential when dealing with data, but negligible when dealing with audio. Even though the CD-ROM too was developed to store a symphony it could be used to store any type of data. Hence, now CD-ROMs are used to store software, data and information for computers.

The CD-ROMs are manufactured by stamping molten polycarbonate plastic with a *Metal Master* (the manufacturing of the master is a complicated process) which is a negative (the lands and pits are opposite) of the actual CD that is being manufactured. The crated polycarbonate wafer is 122mm in diameter and 1.2mm thick with a 15mm diameter hole in the centre. Next the pits and lands are sputter-coated (a continuous coating of metal) with layer of reflective material (Aluminium in most cases). This layer is then spin-coated (coating by spraying while spinning) with a protective layer of acrylic lacquer. Once this is done the CD-ROMs are labeled and ready for use. The lacquer layer and the label may be cured with UV light to protect the aluminium against oxidization.

It is important to note that the original audio, software and data CD-ROMs are manufactured in this manner.

6.3.2.1.1 CD-R

The CD-R is referred to as a WORM (Write Once, Read Many) device. According to this definition it is clear that you can write to a CD-R once and read many times, but the data on a CD-R cannot changed or erased once written and is permanent.

Unlike CD-ROM where the pits and lands are stamped on, in a CD-R a laser beam is used to burn pits into the organic dye layer (this layer is burnt by the laser beam to form a dark patch). This does not physically create a pit shape, but burns the dye layer which turns black and thus does not allow the reflection of light from the reflective layer. By burning only specific areas we can create a situation where some areas are reflective (areas not burnt) and other areas are not (areas that are burnt). Since lands reflect light and pits do not we can replicate the feature of a CD-ROM on a CD-R. This process or writing data to a CD-R is called “burning a CD” since it physically burns the organic dye layer. An unused CD-R is like a CD with no pits and one long land.

The key fact is that CD-R can be read by most CD-ROM drives and audio drives since both CD-ROMs and CD-R have the same feature of reflecting light. But to burn a CD-R you require a special CD Drive (CD-Writer). The CD-Writer uses the same wavelength laser as a normal CD Drive would use read a CD-ROM. But to burn pits into the land, the laser it uses is ten times as powerful as the laser beam used to read a CD-ROM.

Selecting the correct CD-R: There are certain factors that we need to consider when selecting what CD-R to use. The factors should be carefully weighed against the purpose of using the CD-R.

- **Capacity**: CD-R are usually available in 650MiB (682Mb – 74 minutes of audio) and 700MiB (737Mb – 80 minutes of audio) (1 Mebibyte is () bytes and 1 Megabyte is () bytes. Mebibytes are usually used to ? ?). There is only a very small price difference between the two and the most commonly available is the latter. It is important to note that sometime the 700MiB CD-R may not be ecognized by older CD-ROM and CD-DA drives
- **Media Colour**: The CD-R Media colour does not reflect any book like the Red Book of CD-DA. The colour code here compromises of the “reflective” layer and the “dye” layer respectively.
    - Gold-Gold: These are most commonly produced by Kodak, Maxell, Richo and Mitsui. This CD-R has a lifespan of about 100 years. The disadvantage of these CD-R is that they work only on a limited number or drives and are less tolerant of power variations of the read/write laser.
    - Gold-Green: This CD-R is manufactured by Imation, Memorex, Kodak, TDK and BASF. These are more tolerant of power variations of the read/write laser and works with many drives. These have a lifespan of about 10 years, but the more recent Silver-Green version has a lifespan of about 20-50 years.
    - Silver-Blue: These are manufactured by Verbatim, TDK, Maxell and DataLife. These have a similar performance to Gold-Green, but have a much longer lifespan of about 100 years. This CD-R is more suitable for long term archiving since they work on a large number of drives and have a longer lifespan.
- **High reliability**: The CD-R should have a minimum number of errors when writing and reading. Reflective surface dropouts: The CD-R should not have many areas where there is no dye (reflective surface dropouts) since these areas cannot be written to. Durability: The CD-R should be resistant to events of normal handling like scratch proof coatings and anti oxidant paint layers to protect the reflective surface. Compatibility: The CD-R should be able to be written to and to be read from a variety of drives. Cost: The CD-R unit cost should be low.
- **Speed Rating**: The speed rating of a CD-R is the amount data that can be written to it within a unit period of time. The speeds are usually indicated in a value which is a multiple of 1.2Mb. If the data writing speed is 1.2Mb then it has a 1x writing speed, if it is 59.5093MiB it has a 52x writing speed. It is important to consider the speed of the drive and the CD-R when you are going to burn a CD-R. If the speed of the writer is set to a higher speed than the CD-R can handle, it will not burn the

CD-R correctly. It is important to burn CD-R at speeds of 8x or less when you are going to use the burnt CD-R on a older drive, or when you are creating a bootable CD.

6.3.2.1.2 CD-RW

The Orange Book Part III defines the CD-RW standard. CD-RW is a standard for rewritable CDs. CD-RW can be written to about 1000 times. Even though the CD-RW is much expensive than the CD-R, it is much easier since you could use it as a floppy disk, but with much higher capacity. The drawback of the CD-RW is that they have much slower writing speeds and they are less reflective. The latter makes difficult for older drives and CD players to read CD-RWs. This can be verified by the “MultiRead” sign on the drive or player, which implies that it can read CD-DA, CD-ROM, CD-R and CD-RW.

The CD-R drives are now being replaced by CD-RW drives since the CD-RW is fully backward compatible and can handle CD-DA, CD-ROM, CD-R and CD-RW. CD-RW drives usually have three values. In order they indicate record, rewrite and read speeds.

Unlike a CD-R which has an organic dye layer, a CD-RW has a phase change recording layer for recording. The order of the layers from top is:

- Protective lacquer layer – protect the reflective layer
- Reflective Aluminium layer – reflect the laser
- Dielectric layer – to protect the aluminium layer from the extreme heat of writing
- Phase change layer – for writing
- Dielectric layer – to protect the polycarbonate layer form the extreme heat of writing
- Polycarbonate layer

The phase change layer is made up of an alloy consisting of silver, indium, antimony and tellurium. In a normal situation this alloy has a polycrystalline structure which about 20% reflective. When writing the CD-RW the write laser heats the alloy to about 500 to 700C. The alloy melts and loose its polycrystalline structure and creating a liquid state called an *amorphous* state. When the alloy sets from an amorphous state it only has a reflectivity of about 5%. The low reflectivity areas work similar to pits on a stamped CD, and the higher reflectivity areas work similar to lands.

To rewrite to a CD-RW we need to bring back the alloys state to the polycrystalline structure with 20% reflectivity. This is done by using a erase laser which heats the material to about 200that softens the alloy but does not melt it. When the alloy sets from this state it forms the polycrystalline structure that is 20% reflective. Using this method you could create a continuous area which represents a land.

Looking at the temperature difference of writing and erasing the writing laser (P-write) is much more powerful than the erasing laser (P-erase). It is important to note that even though there are two levels of laser energy, it is very rarely that a CD-RW is erased before rewriting. The writer uses a laser level powered to a value between the P-write and the P-erase state to directly overwrite any data on the CD-RW.

Speed rating: Similar to a CD-R the CR-RW has a speed rating. The original CD-RW standard specifies a speed rating from 1x to 4x. Later onwards the next volume of the Orange Book Part III defined the CD-RW writing speed from 4x to 10x. This is known as the High-speed rewritable. The volume of the Orange Book Part III defines a writing speed from 8x to 24x. This is known as the Ultra-Speed rewritable. It is important to note that the CD-RW has to compatible with the drive used. The rule is that the drive has to equivalent or faster that the CD-RW writing speed.

6.3.2.2 Digital Versatile Disc

The DVD originally stood for *Digital Video Disc*. As the original name suggested the DVD was developed for and backed by the movie industry. A single-sided single layer DVD could store 240 minutes of *Moving Picture Expert Group-standard 2 (MPEG-2)* (method of encoding video). But later onwards the DVD was used for other purposes and hence, is now referred to as the *Digital Versatile Disc* (figure 6.15).

Figure 6.15: DVD

Digital Versatile Discs or in short DVDs use the same technology as the CDs. The only difference between DVDs and CDs is that the DVD has a much higher data density on a similar sized disc. CDs have a maximum data capacity of about 737Mb but a DVD can store about 4.7Gb of data on a single layer DVD and 8.5Gb on a double layer DVD. Furthermore double-sided DVDs can store double the amount of a single-sided DVD (currently the DVD needs to be flipped over to read the opposite side). The most advanced DVDs which use Blu-Ray technology can store up to about 27Gb of data. DVDs have smaller pits and lands, and they are much closer together that a CD. The pits and lands are about four times denser in DVD than a CD.

The DVD drive which is used to read DVDs, use similar technology to CD drives. The difference is that the DVD drive is much more precise, but it is important to note that most DVD drives can also read CDs. DVD drives use a laser with a shorter wavelength to read the smaller pits and lands. The second layer of a double-layer DVD is semi-reflective, that makes it possible to read the first layer (the first layer of the DVD is the layer nearest to the label, and the second layer is the nearest to the read lens of the DVD drive). In a double layer DVD-ROM the different layers are read by focusing the laser on to the respective layer.

There are many compatibility issues in DVD technology due to the reason that there are two groups who define standards. The first is the *DVD Forum* and the second the *DVD+RW Alliance*. The DVD Forum announced the DVD-ROM, DVD-RAM, DVD-R and DVD-RW. The DVD+RW Alliance announced the DVD+RW and the DVD+R. When purchasing DVDs and DVD Drives it is important to consider these compatibility issues.

6.3.2.2.1 DVD-ROM

DVD-ROMs are similar to CD-ROMs but have a much higher data density. The DVD-ROMs are manufactured in the same manner as CD-ROMs by stamping molten polycarbonate plastic with a Metal Master that is a negative of the DVD-ROM needed to be manufactured. The difference is that the each layer of the DVD-ROM is separately stamped using a different Metal Master, and then bonded together. If there are two layers there would be two separately stamped layers bonded together, whereas if there are four layers there would be four separately stamped layers bonded together. Irrespective of the number of layers the thickness of a DVD is 1.2mm. The layers are coated with a thin layer of reflective metal. In a double layer DVD-ROM the outer layer has a much thinner layer of reflective metal so that is allows the laser to penetrate through to the inner top layer.

6.3.2.2.2 DVD-R

The DVD-R, similar to the CD-R uses the same technology for writing. The DVD-R has an organic dye layer that is burnt during the process of writing. The DVD-R is also a WORM storage device. The DVD-R has a storage capacity of 4.7Gb of data on a single-sided disc and 9.4Gb on a double-sided disc. The tracks in a CD-R wobble (a wave pattern) from left to right. These wobbles provide a clock signal. These are much cheaper that DVD-RW discs.

6.3.2.2.3 DVD-RW

The DVD-RW uses the same phase-change technology as CD-RW. The original DVD-RW standard had a speed rating of 1x. The modern DVD-RW has a speed rating of 2x.

Like the CD-RW drive, the DVD rewriter drives were designed to handle both DVD-RW and DVD-R. The older drives worked at 1x/2x (DVD-RW/DVD-R). Modern drives work at 2x/4x. It is important to note that DVD-RW discs are not compatible with many drives, especially older ones.

6.3.2.2.4 DVD+RW

The DVD+RW has become much more popular than the DVD-RW since it much more cost effective and works with most DVD readers and writers. Another advantage of the DVD+RW is that it has positioning information embedded into to it that enables faster and more accurate positioning of the laser. Furthermore the wobble in the grove which provides the clock information has a different frequency that the CD-R/RW. The disadvantage is that DVD+RW drives cannot be used to write to other DVD writable media. Similar to a DVD-R the DVD+RW has a storage capacity of 4.7Gb of data on a single-sided disc and 9.4Gb on a double-sided disc. The speed rating ranges from 1x to 4x.

6.3.2.2.5 DVD+R

Unlike CD-R which lead to the CD-RW and DVD-R which lead to DVD-RW, the DVD+R did not lead to the DVD+RW. Instead the DVD+RW lead to the DVD+R. This was to make it more cost effective for permanent data storage. Furthermore the DVD+R made it possible for the data to be read by some drives which did not previously read DVD+RW discs. It is also important to note that some DVD+RW drives cannot write to DVD+R discs.

DVD-RAM

DVD-RAM is a writable DVD standard. Unlike CD-R or CD-RW, and DVD±R/RW, DVD-RAM records on both land grooves and pit grooves. When DVD-RAM was introduced it had a capacity of 2.6GB and 5.2GB for a single sided and a double sided discs respectively. But with the release of DVD-RAM version 2, it increased the capacity of a disc to 4.7GB and 9.4GB respectively. The only drawback of DVD-RAM and the reason for it not being as popular as other DVD writables is that it is not backward compatible with DVD-ROM, hence it cannot be read by a DVD-ROM reader. Furthermore older DVD±R/RW writers can not write to DVD-RAM discs. The backward compatibility issues with DVD-ROM were irradiated with the introduction of the *MultiRead2* specification, and the problems of writing to DVD-RAM and DVD±R/RW using the same writer was irradiated by the *DVD Multi* specification.

The writing of the DVD-RAM occurs by the writing laser burning areas in the crystalline are of land grooves or pit grooves, causing the particular spot to be amorphous, which then becomes less reflective. When the read laser passes over a border from a crystalline area to a amorphous area or vise versa, it will read it in a similar manner to reading a DVD-ROMs lands and pits.

6.3.2.2.6 DVD±R/RW and DVD Multi

The DVD±R/RW drives can be used if you need to use DVD-R, DVD-RW, DVD+RW and DVD+R discs to write data. It is an important to fact to note that DVD±R/RW drives are much more expensive than DVD-R/RW or DVD+R/RW drives. But DVD±R/RW drives give you more flexibility.

Another drive is the DVD Multi drive which is compatible with all DVD Forum standards. These drives support DVD-ROM, DVD-R/RW, DVD-Video and DVD-RAM. These drives do not support DVD+R/RW since it is not a DVD Forum standard. The best option is to choose a DVD±R/RW if you want to purchase one.

6.3.3 Flash Memory

Flash memory is a non-volatile type of memory. This uses the EEPROM technology used in many of the modern BIOS chips. Since flash memory can be erased electronically, easily rewritten and is not volatile it is commonly used for storing data. It is important to note that flash memory has to be erased before it can be written into (The driver allows this function, without the user noticing it happening). Flash memory is highly compact, that storage in the range of gigabytes is supported on devices as small as a stamp. The size, portability and cost have made flash memory one of the most commonly used types of removable storage for computers and digital devices.

There are many different types of flash memory devices. Most of the digital devices that use these cards have serial or USB connectors that can connect to the computer. The disadvantage is that the data transfer rate is dramatically reduced when this method is used to transfer data from the flash memory card to the computer. Other than the USB Flash Drive, other flash memory cards use special adapters known as card readers, PCMCIA card adapters or Floppy adapters to connect flash cards to the computer directly. This allows high speed data transfer between the flash memory card and the computer.

In general there are some key issues to consider when purchasing flash memory.

- The type of flash memory your device is designed to use – even though some devices support multiple types of flash memory, for best results it is wise to use the type of flash memory the device was originally designed for.
- The maximum capacity of the flash memory your device supports – even though you could plug in higher capacity memory, the device will only use the maximum it is designed for. The balance memory of the flash memory will be wasted.
- What is the best flash memory device – One flash memory device may have higher capacity, faster writing and reading speeds, encryption and better memory controllers than others.

6.3.3.1 USB Flash Drive

USB-based flash memory is also known as key-chain drive, ThumbDrive (figure 6.16), Pocket clip drive or pen drive (These terms have been used to emphasise its size and portability). Unlike other flash memory cards, the ThumbDrive does not require a special reader but simply plugs into the any USB port of the computer. Most modern operating systems are equipped with the necessary drivers and the ThumbDrive is easily ecognized by them. Once the drive is detected it is displayed as a *Removable Storage Device*. It is important to note that older operating systems do not have the drivers required by the ThumbDrive to function as soon as it is plugged in. In such a case you have to install the compatible ThumbDrive driver to the respective operating system.

Figure 6.16: Thumbdrive

With the introduction of the ThumbDrive the popularity of older removable storage devices like the Floppy disk, Zip disks and SuperDisks have subsided. The maximum storage capacity of these older devices is about 100Mb, but the modern ThumbDrives have a storage capacity of over 2Gb and do not require special disk drives to read and write to them.

Some important aspect to consider when purchasing a ThumbDrive is the:

- Capacity – Consider the larges file size you would be transferring through your ThumbDrive. If you transfer large files such as video, audio, databases and image files, you will require a larger capacity drive. Furthermore if you are just transferring small files from one computer to another, you will require a small capacity drive. If you will be using the drive to keep backups of files you require a larger drive.
- Speed – The USB1.1 ThumbDrive will read/write data at about 1Mbps (megabytes per second). A High-Speed ThumbDrive which is USB2 compatible will transfer at a rate ranging from 5Mbps – 15Mbps. Hence, it is important to consider the speed of the ThumbDrive.
- Price per Megabyte – When buying a ThumbDrive it is important to calculate the price per megabyte and see what options you have according to your requirement.
- The more advanced of these ThumbDrives additional features like:
    - a mechanical write protection switch
    - password protected data encryption
    - capability of being a bootable device

When you finish using your ThumbDrive, it is important to use the eject function of the operating system before you remove it from the computer. The reason for this being that there could be conflicts between device drivers and the data on the ThumbDrive could be corrupted.

6.3.3.2 SecureDigital(SD) card and MultiMediaCard(MMC)

We will discuss the SD and MMC card (figure 6.17) together since they are of similar in shape and size, and many devices supports the other if it uses one. SD cards and MMC are used in digital cameras, video cameras, smart phones and Multimedia players.

Figure 6.17: SD card

The MMC was modified to be about 40% of its original size to form the Reduced Sized MMC (RS-MMC or R-MMC). This provided the ability extend the memory of smaller devices such as mobile phones.

The major difference between the SD card and the MMC are:

- The SD has a security feature to enable encrypted storage (This is how the word “Secure” came to the SD card), but the MMC card stores data in an unsecured way.
- The SD has a mechanical write protection switch to protect data, but the MMC does not have this feature.
- The extension of memory in PDAs is usually done using SD cards.

6.3.3.3 XD-Picture Card

XD-Picture card (figure 6.18) as the name suggest, is commonly used for digital cameras. The main supporter of the XD-Picture card is Olympus and Fujifilm The XD-Picture card is the smallest flash memory card as yet. Other advantages are that it is much more durable than other flash memory cards and has faster controller to store images much faster (this is important for taking photographs in quick succession). The write speed of XD-Picture card ranges from 1.3Mbps to 3 Mbps, and the read speed is about 5Mbps. Another important fact to consider when purchasing XD-Picture cards is that you need to buy a card that supports the particular camera. The reason for this is that each card is ustomized for the particular camera brand. For example the Olympus XD-Picture card supports "Panorama view" (A set of photos can be taken to form a panoramic view – same height but the width of the photograph is increased).

Figure 6.18: XD card

6.3.3.4 Compact Flash Card (CF)

The CF card (figure 6.19) was developed by ScanDisk Corporation and uses the ATA technology which emulates a hard disk (When the card is plugged into the computer it is assigned a drive letter just like a hard disk). The CF card is currently has the highest storage capacity of all flash cards.

CF cards come as Type I and Type II. The only difference between them is their thickness (Type I is 3.3mm thick and Type II is 5mm thick). These cards are easily pluggable to the PCMCIA slot of notebook computers by using a CF-PCMCIA adapter. CF cards are also commonly used in professional digital cameras where taking photographs in quick succession and high storage is a key factor.

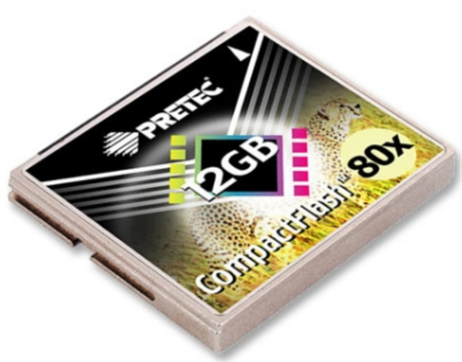

Figure 6.19: CF card

6.3.3.5 Memory Stick

The Memory Stick (figure 6.20) was developed by Sony Corporation. This card is commonly referred to as the “Sony-Memory Stick” since Sony has the proprietary rights to this type of flash memory. Sony is a major manufacturer of notebook computers, digital cameras and camcorders. Hence, it has developed the Memory Stick for its devices. The Memory stick comes with a manual write protection switch and advanced version of the Memory Stick has an encrypting feature and a high speed memory controller.

Figure 6.20: Memory Stick

6.4 Taking Backups

Before going into detail let us first understand what a backup is. A backup is defined as a duplicate copy of the data on your hard disk that is archived on another storage device, such as a hard disk, a CD/DVD or a tape. The key issue here is to store a copy of your computers most recent data in a different geographically location (off-site storage) to that of your computer. We will address the issues of backup in the form of some simple question.

Why do I need to take backups?

The data on your computer can be lost due to many reasons. Some of them are listed below.

- Hard drive failure: The hard disk could fail due to many reasons.
- Overwriting a file by mistake.
- Formatting your hard disk by mistake.
- Destruction or corruption of data by malicious programs like viruses.
- Power fluctuation that could destroy your computer or damage your data.
- Damage of destruction of your computer by a disaster like fire, floods, lightning strikes and theft.

Backing up of data is much easier to do, cheap and takes only a little time to do, when compared to data recovery which is a very difficult, expensive and time consuming. Furthermore data recovery does not grantee that you will be able to recover your data from a system crash. Backing up of data ensures that your data is secure in case of disaster and that you have copy of your original data so that your data loss in minimal.

What data do I need to backup?

You need not backup every single file in your hard disk. Most files are common and can be replaced easily. Files like the operating system files, program files need not be backed up. Files which are unique and can not be easily found from another source like:

- Office files (document files, spreadsheet files, presentation files)
- image, audio and video files you have purchased or developed yourself
- Databases
- Address book
- Scheduler, Planer and Bank and Financial records
- Bookmarks of your web browser
- Software you have purchased (installation files and the serial numbers)
- Personal projects (Books, software, designs)
- Other important files

How often do I need to take backups?

Backups should be performed on a regular basis. The frequency of backing up data depends on the amount of work that would be lost in the event of a catastrophic failure. For example if you are a system administrator you would need to take backups of you databases, file servers data, mail servers data and web servers data probably every 24 hours. But if you only need to backup your home computer, this can be scheduled for once a week or may be even once a month. It all depends of the amount of data, value of that data and the amount of work done to produce that data.

It is important to note that data backups do not offer a comprehensive solution for data protection. This is due to the reason that the data backed up might be corrupted during backup. To avoid this it is important to test whether the backup is correct and can be restored. Furthermore the data in the backup does not have the updated data between the most recent backup and the failure.

The most important files need to be backed up every time you modify them to ensure that you have the most updated version.

How do I choose the backup medium?

There are many mediums available for backing up your data. Listed below are some of them.

- Magnetic Tape: This is one of the most economical backup devices available. Tapes have a large data capacity, in many cases much more than even a DVD. The disadvantage of the magnetic tape is that the data on those tapes can only be accessed sequentially (one after the other).
- Removable drives: Removable hard disks, ThumbDrives, Zip drives, SuperDisks and Jaz drives fall into this category. The removable hard disk has a very large data storage capacity where as the ThumbDrive may have about one or two gigabytes of storage capacity. The other drives have storage capacity measured in megabytes. The advantage of these devices is that they are random access devices and provide all the advantages offered by random access devices like overwriting files and fast access.
- Optical devices: Writable or rewritable CD and DVD fall into this category. These devices provide a data storage capacity ranging from about 650Mb on a CD-R/RW to about 9.4Gb on a double sided DVD±R/RW. These drives have all the advantages of random access medium. Writable or rewritable CD and DVD are usually used for permanent backup of data, but the CD-RW and the DVD±RW can be used for temporary backup. The older version of the file can be overwritten by the most recent version of the file in a rewritable CD or DVD.
- Network: Networked computers can store copies of their data on another computer in the network. This is an alternative to using removable media drives. The disadvantage of this method of backup is that viruses can travel over a network. Another disadvantage is that if all the computers are in one location there is no off-site storage and a disaster like fire or floods could destroy all the data. A solution for this is to use a central serve for backing up of individual networked computers and then obtain a backup of the data in this central server and store it in an off-site location.